

SMPTE STANDARD

Calibration Reference Wideband Digital Pink Noise Signal



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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual.

SMPTE ST 2095-1 was prepared by Technology Committee 25CSS.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

Pink noise is the most commonly used and ubiquitous test signal for the acoustic level and spectral calibration of sound systems. Pink noise was originally chosen for this task because it has characteristics that are similar to the way human spectral hearing perception works, which is that we roughly hear in an equal energy/octave manner.

Though pink noise can be generated by many different types of devices, there is no standard pink noise signal that all devices emulate. Nor is there a published standard that specifies exact parameters and values for calibration pink noise. Therefore, while many of today's field devices generate a usable pink noise signal, all of these signals are somewhat different. This presents a basic variable in the calibration process, as sound system calibrations designed to obtain the same results among many different systems are being performed with different test signals.

In the days of analog soundtracks, test tapes and test films were available from respected laboratories, so there was some agreement on the test signals that were utilized in the industry. Since the advent of digital sound reproduction, no standard has been in place for generating digital pink noise signals.

This document delineates the parameters and values for a standard digital pink noise signal that can be used for level and spectral calibration. In specifying these parameters and values, the subject of how to determine the level of a pink noise signal is discussed. See Annex C for an informative discussion of pink noise measurement methods.

Annex A describes an executable computer program file in the Python 2 programming language, and .wav files generated by that program, all provided separately. Annex B of this document includes a sample implementation of a compliant software-based pink noise generator presented as pseudocode.

Not addressed in this document are the various use cases where a pink noise signal may be employed, and the conditions that may affect the outcome. Such matters are best left to standards documents such as SMPTE ST 202:2012, SMPTE RP 200:2012, and AES17-1998 (r2009).

1 Scope

This standard defines a digital pink noise signal to be used in calibrating the sound pressure level and electroacoustic response of a cinema B-chain system. It also defines an example algorithm to generate compliant LPCM pink noise signals in DSP devices with sampling rates of 48.00 kHz and 96.00 kHz. It does not define pink noise signals that may be used for other purposes such as headroom, distortion, or other system measurements.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions that, through reference in this text, constitute provisions of this recommended practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this recommended practice are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE RP 200:2012, Relative and Absolute Sound Pressure Levels for Motion-Picture Multichannel Sound Systems — Applicable for Analog Photographic Film Audio, Digital Photographic Film Audio and D-Cinema.

AES17-1998 (R2009), AES Standard Method for Digital Audio Engineering — Measurement of Digital Audio Equipment.

4 Terms and Acronyms

4.1 0 dB FS

The RMS level of a 997-Hz sine wave whose positive peak value reaches Full Scale Digital. (Note: This may be depicted as “0 dBFS” in some literature. The meaning is the same.)

4.2 Audio sampling rate

The number of audio samples per second, measured in Hz or kHz (one kHz being 1,000 Hz). For example, 48,000 samples per second can be expressed as either 48,000 Hz, or 48.00 kHz.

4.3 Average Responding Meter

An average responding meter measures the mean of the absolute value of sample values (or instantaneous values) but is calibrated to indicate the RMS value of the waveform when driven with a sine wave. Because the ratio of average to RMS varies with the type of waveform, such a meter can read the RMS value of sine waves accurately, but such a meter will read the RMS value of other waveforms incorrectly.

4.4 Crest factor

The ratio of peak value to RMS value of a waveform, in dB.

4.5 dB FSD

RMS value relative to FSD. (Note: This may be depicted as “dBFS” in some literature. The meaning is the same.)

4.6 FSD

Full Scale Digital. The maximum numeric value capable of being stored in the bit depth of a digital signal path. Example: A full scale sine wave has positive peaks with a value of 7FFFFFFF (hex) and negative peaks with a value of 800000 (hex) in a 24-bit digital audio system.

4.7 Kurtosis

A measure of whether the data are peaked or flat relative to a normal distribution. The Kurtosis for a normal distribution is 3. The “excess kurtosis” for a normal distribution is 0.

4.8 Peak value

The absolute magnitude of the highest peak amplitude excursion of a signal.

4.9 Pink noise

Noise whose power spectral density (W/Hz) is inversely proportional to frequency and whose power per octave (W/octave) is constant.

4.10 Pinking filter

A filter that converts white noise to pink noise. A pinking filter has a frequency response of -3 dB/octave.

4.11 Root mean square (RMS or rms)

The square root of the mean of the squares of sample amplitudes. Different waveforms with the same RMS value will deliver the same amount of power. The RMS value of a sine wave is $1/\sqrt{2}$ times its peak value.

4.12 Skewness

A measure of the lack of symmetry. The skewness for a normal distribution is 0.

4.13 Unique signal period

Period over which no portion of a noise signal repeats itself.

4.14 White noise

Noise whose power spectral density (W/Hz) is constant and whose power per octave (W/octave) is proportional to frequency.

4.15 Wideband pink noise

A testing reference signal that includes all frequencies within the bandwidth of a measuring system.

5 Summary of Characteristics

Table 1 summarizes key characteristics of the Calibration Reference Wideband Digital Pink Noise Signal.

Table 1 – Digital pink noise characteristics

Parameter	Value	Reference
RMS Level, full spectrum	-18.5 dB FS	Section 6.2
RMS Level, 22.4 Hz – 22.4 kHz	-19 dB FS	Section 6.1
Target RMS Level, any 1/3-octave from 20 Hz to 16 kHz	-33.74 dB FS	Section 6.2
Crest factor	11.5 – 12 dB	Section 6.3
Pink Noise signal bandwidth	10 Hz – 22.4 kHz	Sections 7.2, 7.3
Energy uniformity	± 0.25 dB for any 1/3-octave band from 20 Hz – 16 kHz	Section 7.4
Minimum unique signal period	10 seconds	Section 9.1

6 Signal Amplitude

6.1 Level Criteria (Informative)

In order to ensure consistency with the calibration level of dubbing theatres and the level of soundtracks produced over the past several decades, the digital pink noise level defined in this Standard is intended to be consistent with widely accepted reference noise signals that are currently used in movie soundtrack production.

It should be noted that historical discussions of pink noise level are based on SMPTE RP 2002, which defines the reference level of wideband pink noise as being -20 dB FS when measured by an average-responding voltmeter with a bandpass filter of 22 Hz to 22 kHz.